



Johnson Matthey
Catalysts

Ultrafines from Emission Control Devices: Results from the Real World

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Johnson Matthey Inc.
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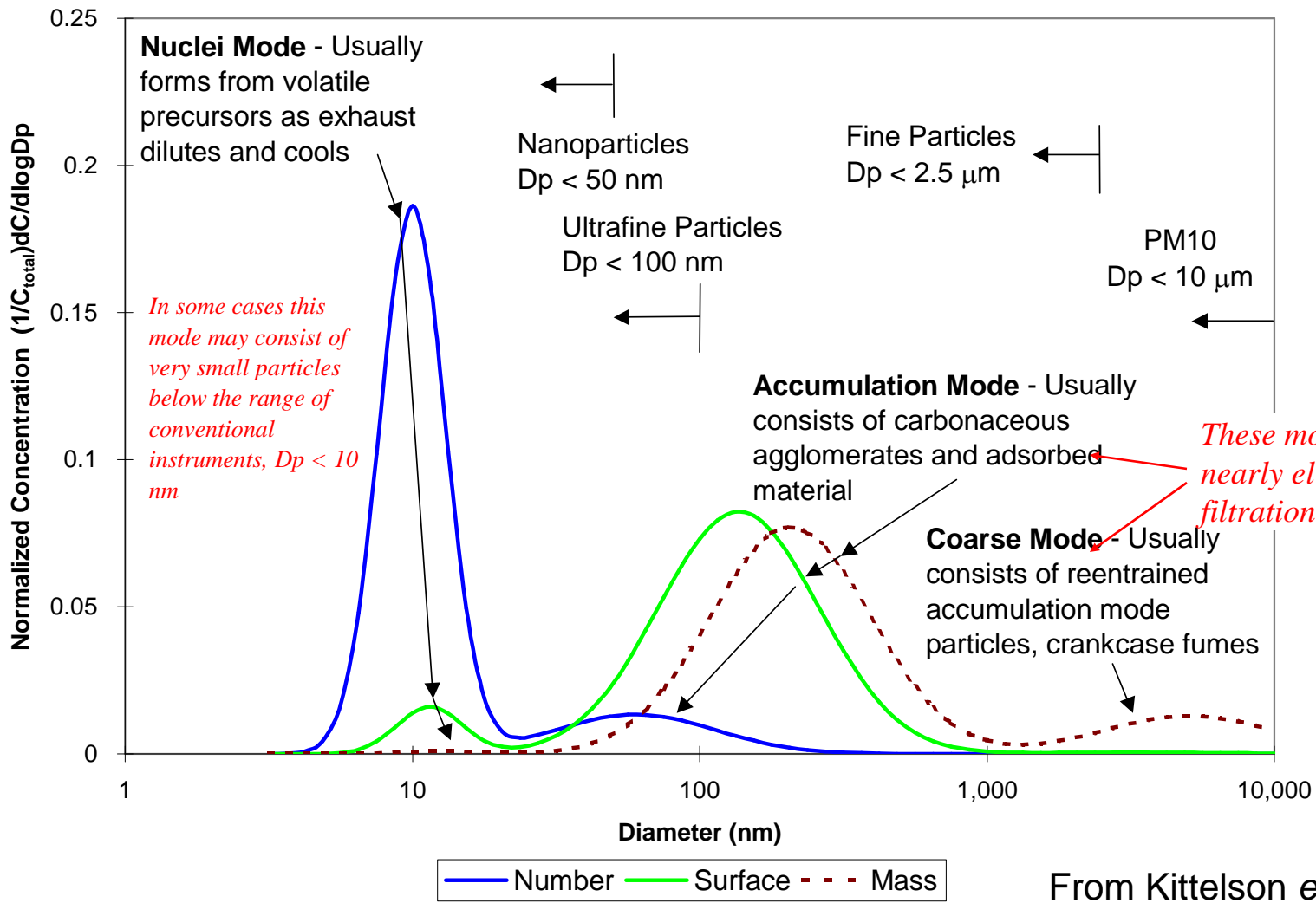
- Johnson Matthey CR-DPF System:
 - Extremely effective at removing 95%+ of engine-out particle **mass** emissions
 - Tests on particle **number** emissions have raised concerns about role of CR-DPF in formation of ultrafines
 - Previous work has suggested that these particles could be **sulfate** and/or **volatiles** (Kittelson *et al.*, CRC E-43 Final Report)



- What Could It Be?
 - Observed ultrafines are sulfur and/or volatiles-related
- How Can We Check?
 - Treat CR-DPF system as a “black box” and see what happens when we:
 1. Control sulfur content IN
 2. Control sulfur content OUT
 3. Control volatile content OUT



Particles Of Different Sizes Are Formed Differently

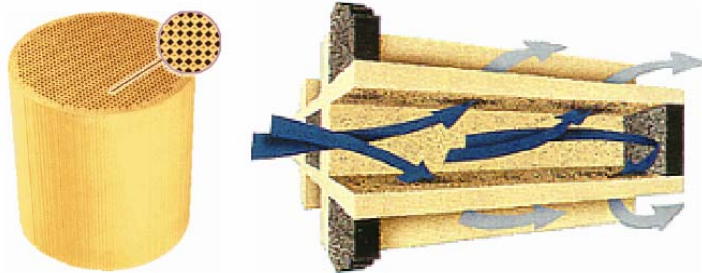


Emission Control Systems

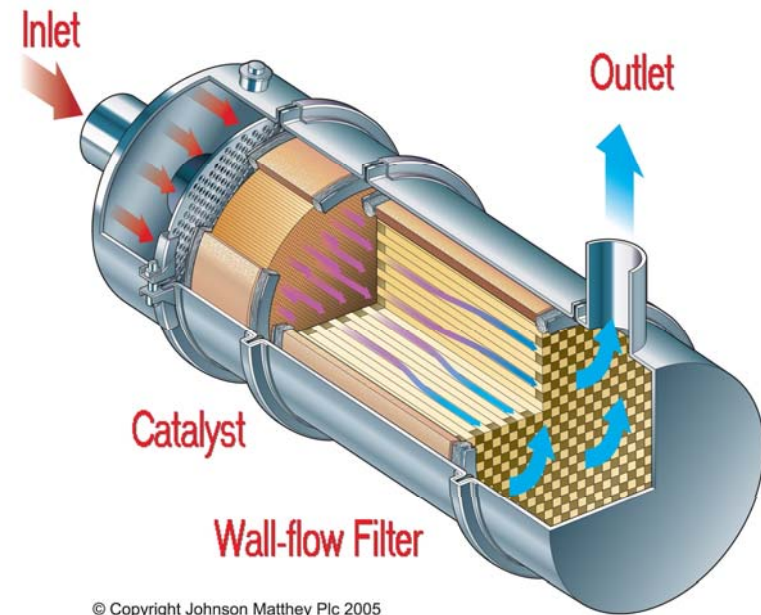
Extremely effective at Diesel PM removal



(a)



(b)



- a) Wall-Flow Filter (courtesy Corning, Inc.)
- b) JM CR-DPF (DOC + Wall-Flow Filter)



How Did We Test? (1)



- All tests conducted on U of M MEL
- Year 2000, 12 L, 12 cyl 287 kW engine
- 65 mph cruise on Minnesota rural freeway



How Did We Test? (2)



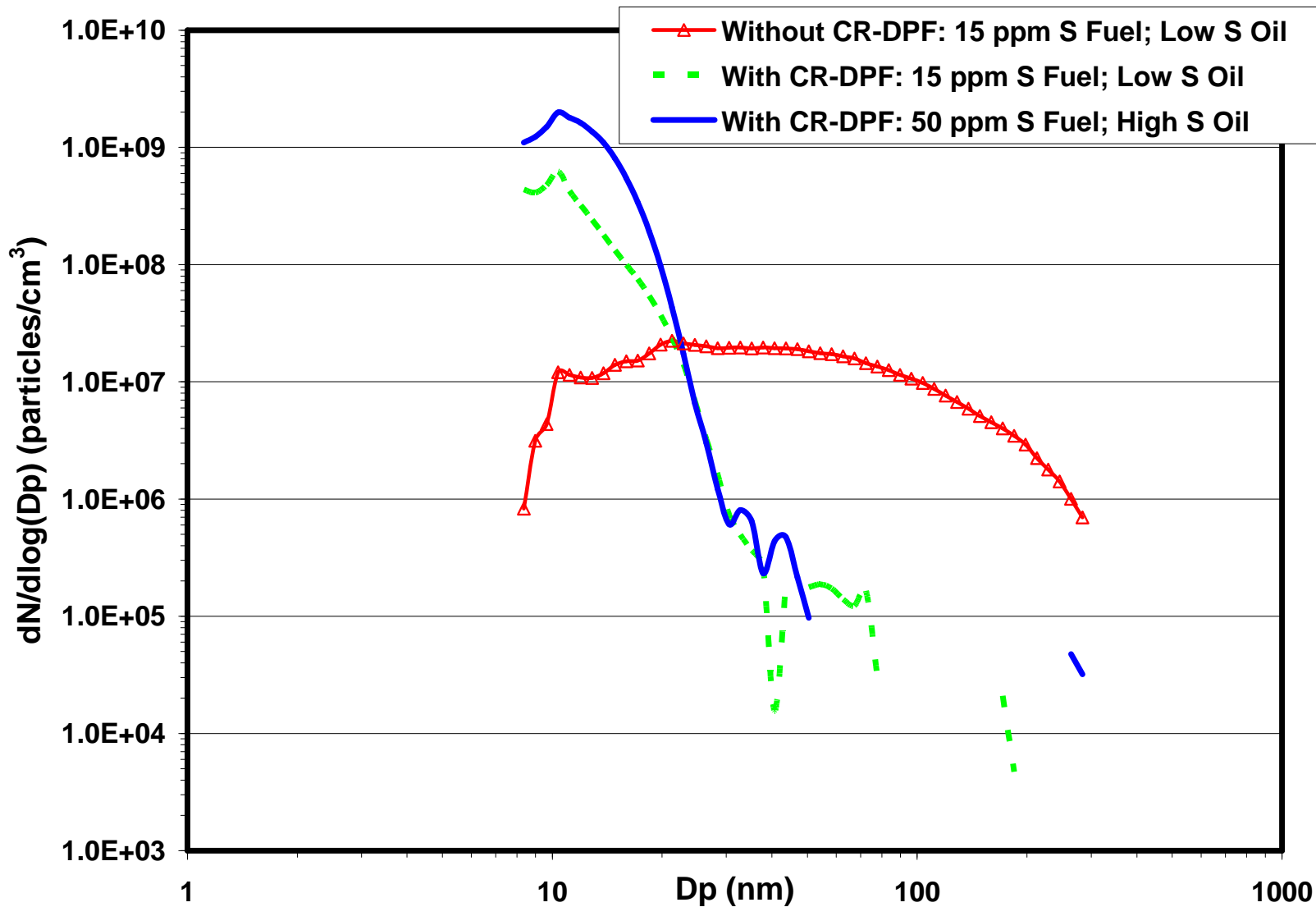
- Control of S IN:
 - 50 ppm S fuel + ~5000 ppm S lube oil
 - 15 ppm S fuel + ~1500 ppm S lube oil
- Control of S OUT:
 - Use of low S fuel + low S lube oil
 - System tested with and without S trap
- Fuels from BP (15 ppm S: ULSD—2007 compliant), lube oils from Castrol
- Control of Volatiles OUT:
 - Use of a catalyzed CR-DPF



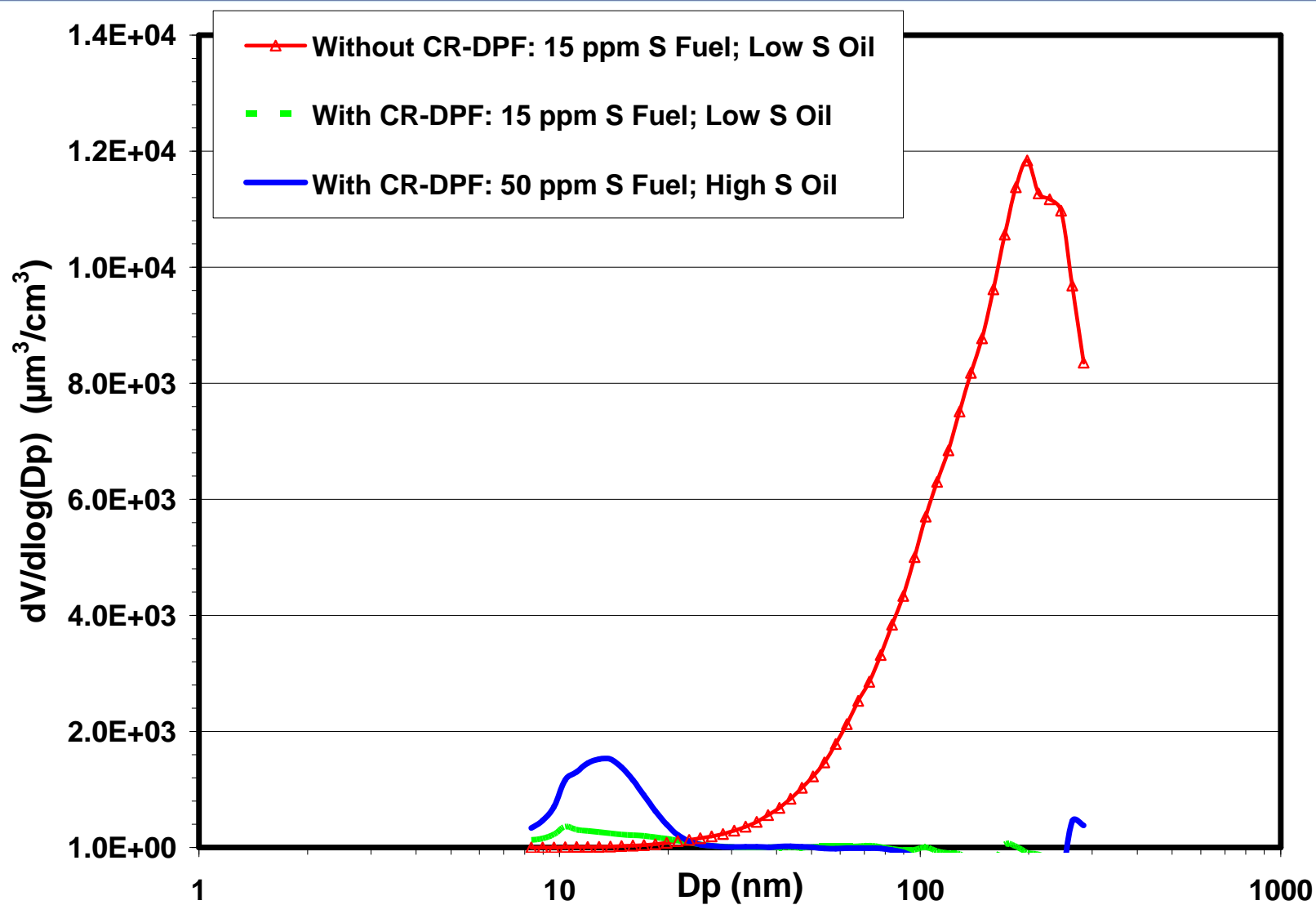
1. Control Sulfur Content IN



Lower Sulfur In → Lower ultrafine number out



Lower Sulfur In → Lower ultrafine mass out

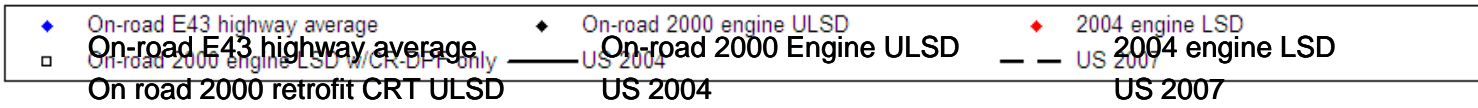
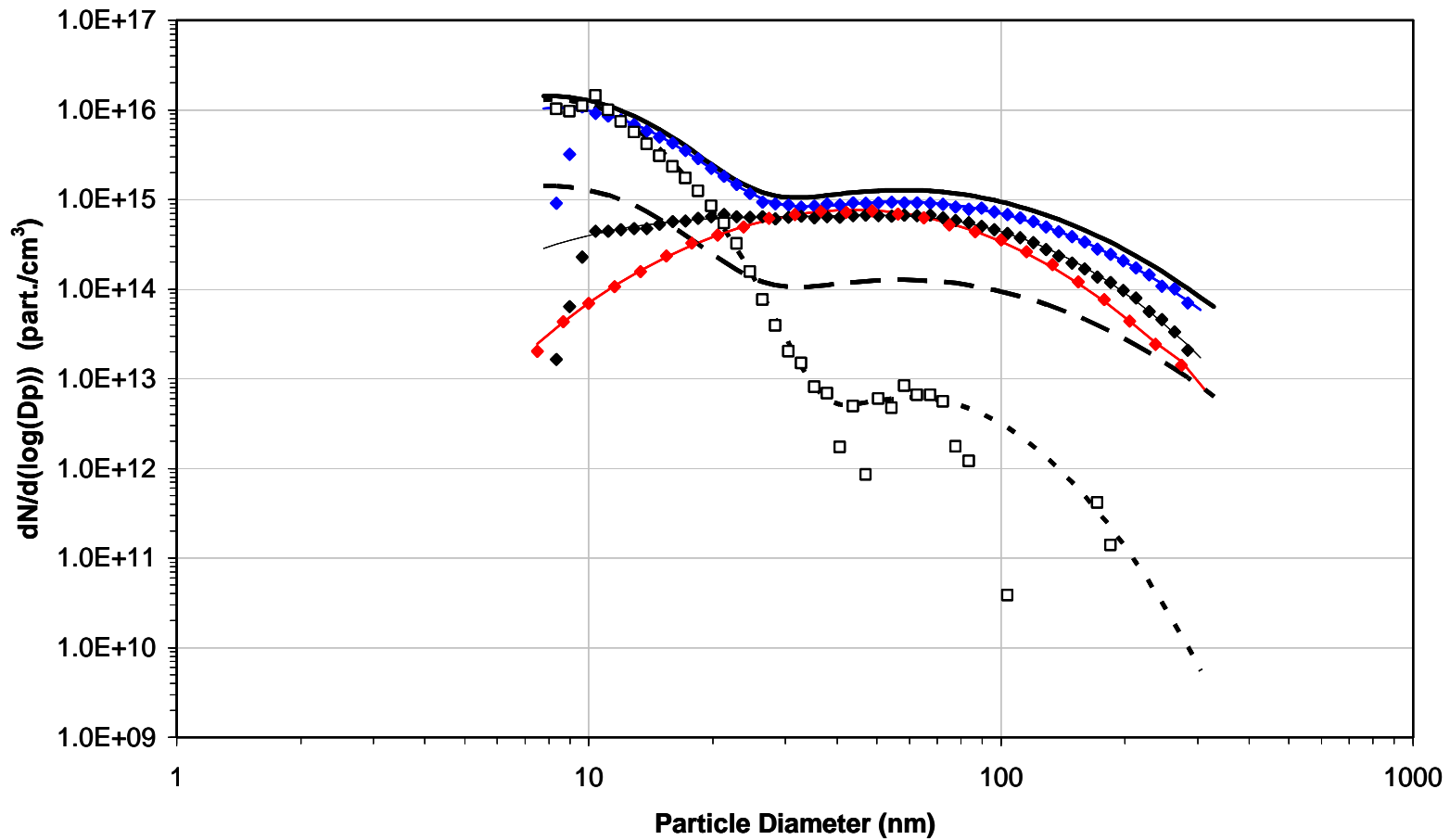


2. Control Sulfur Content OUT

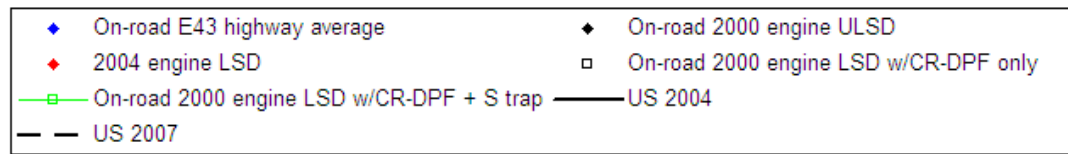
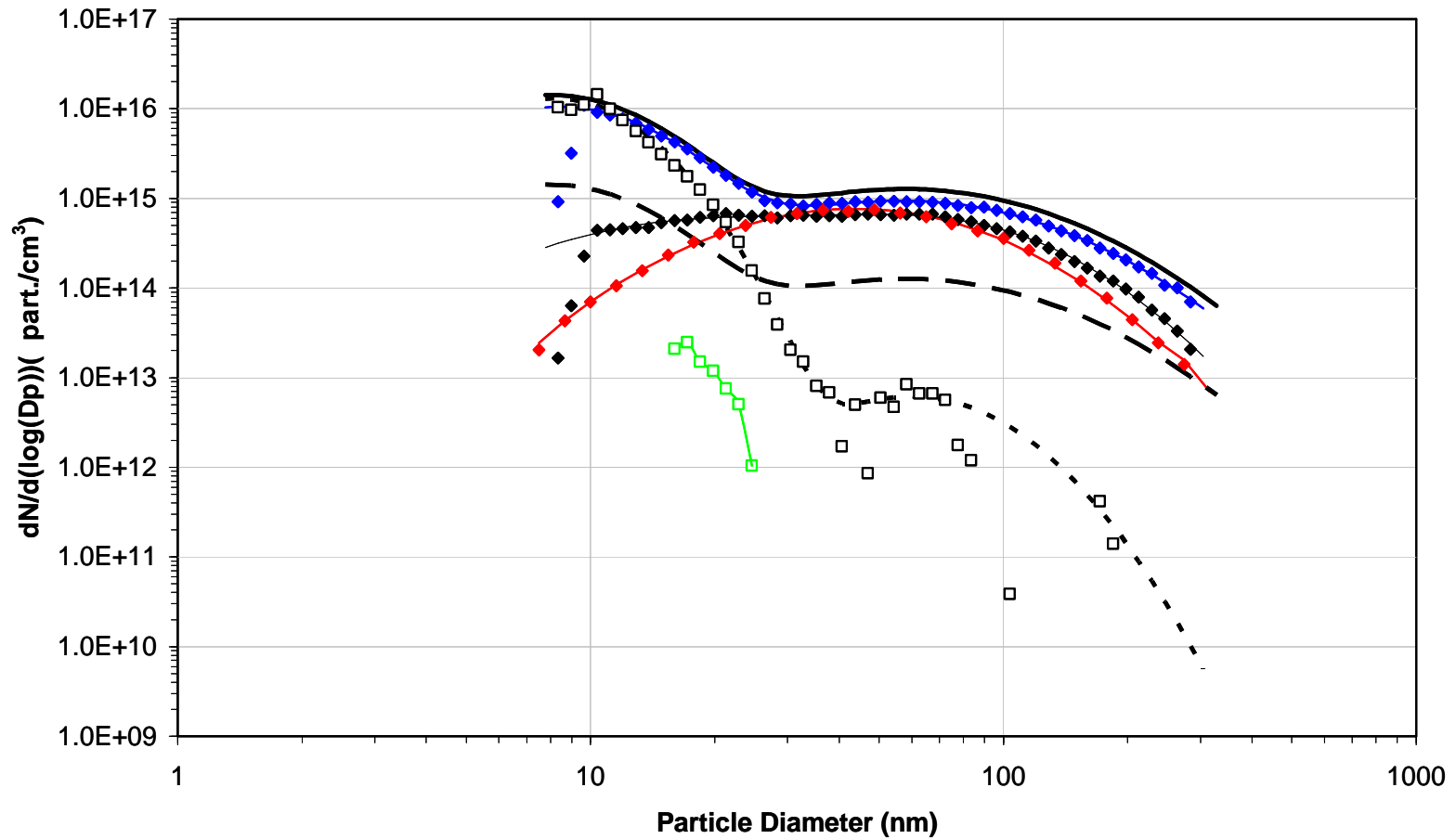


Ultrafine number

No Sulfur control OUT

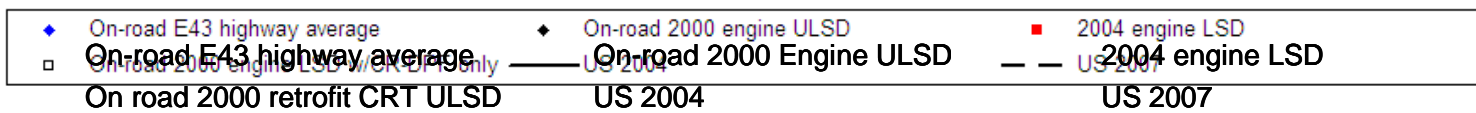
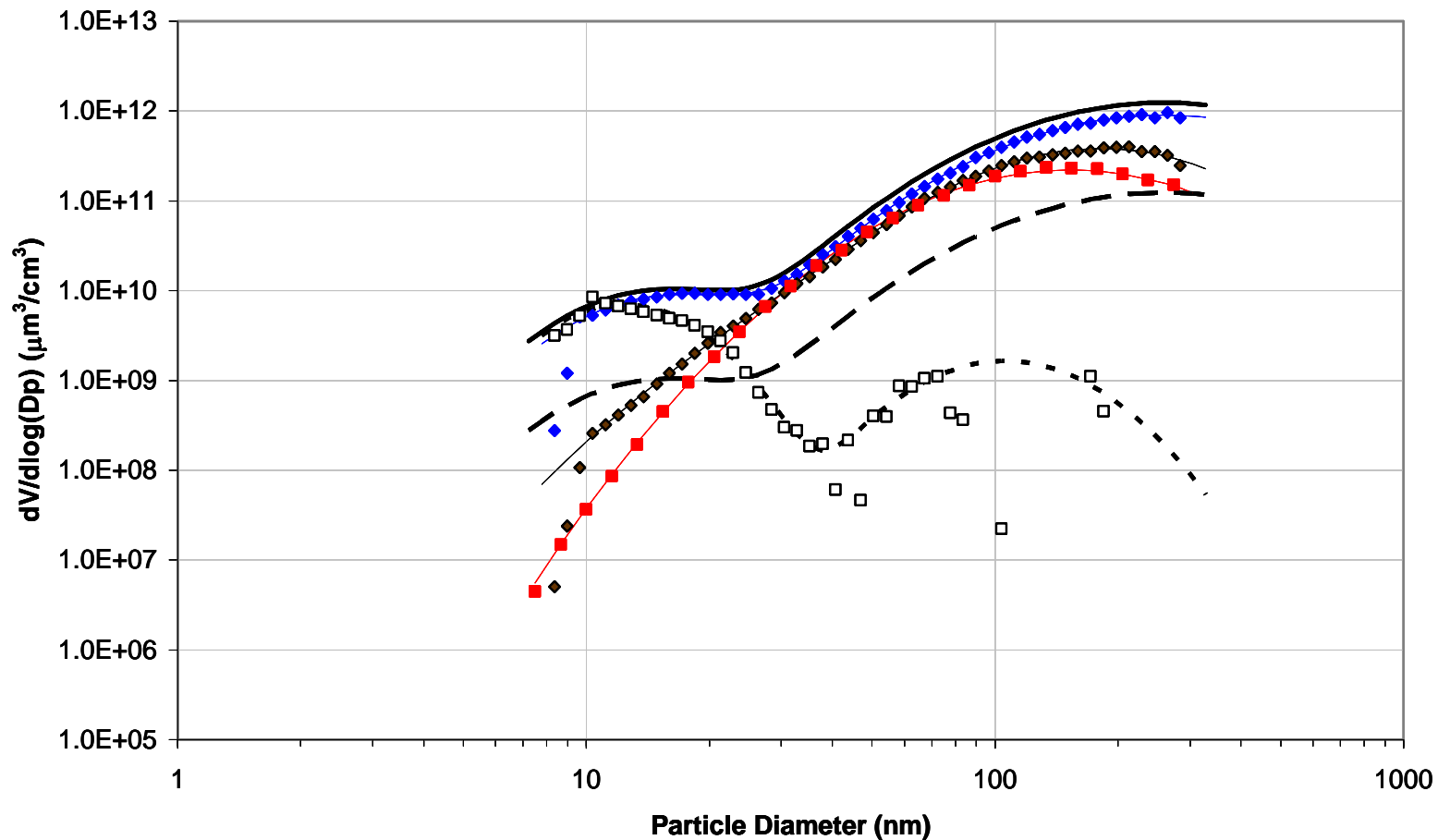


Ultrafine number Sulfur control OUT

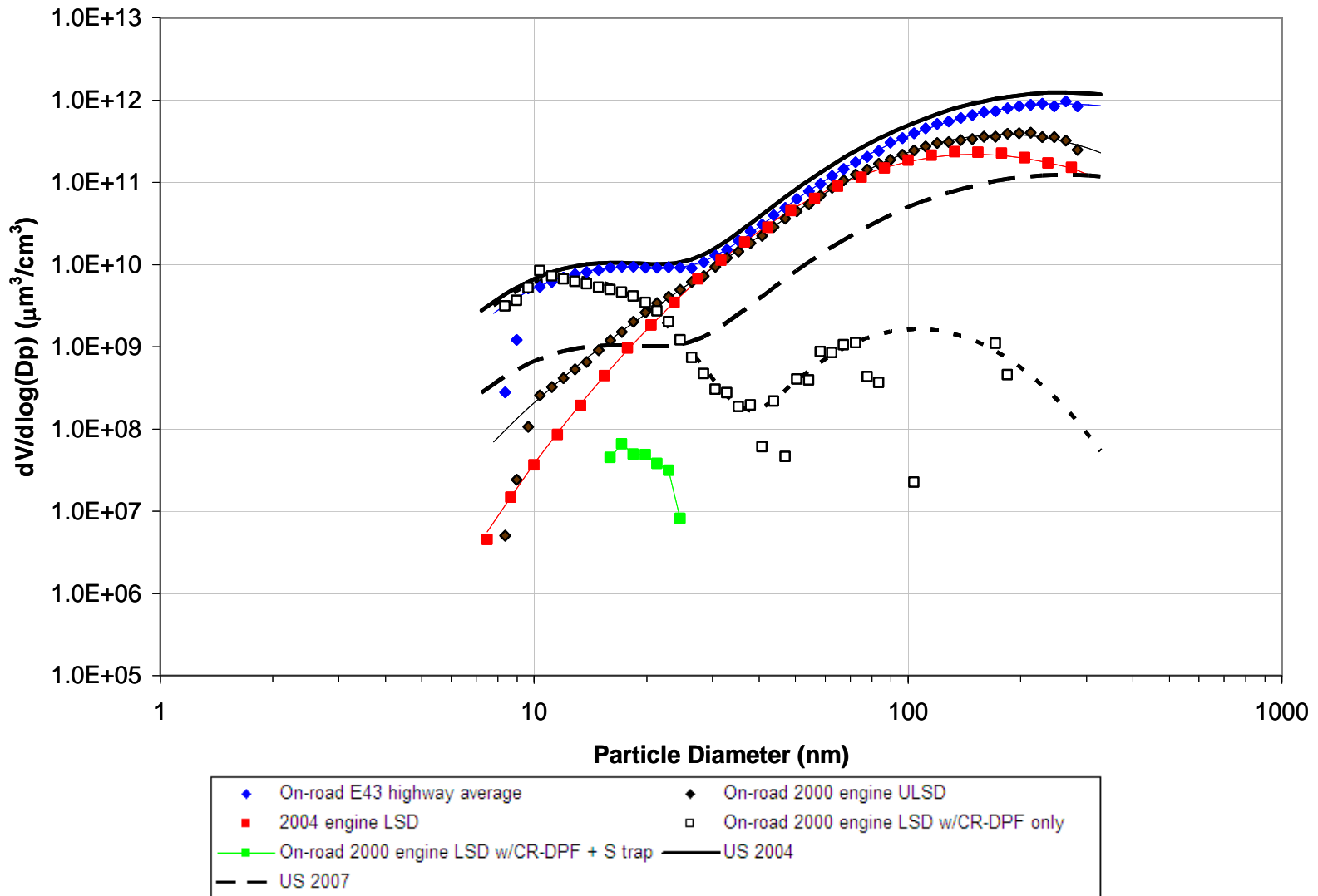


Ultrafine mass

No Sulfur control OUT



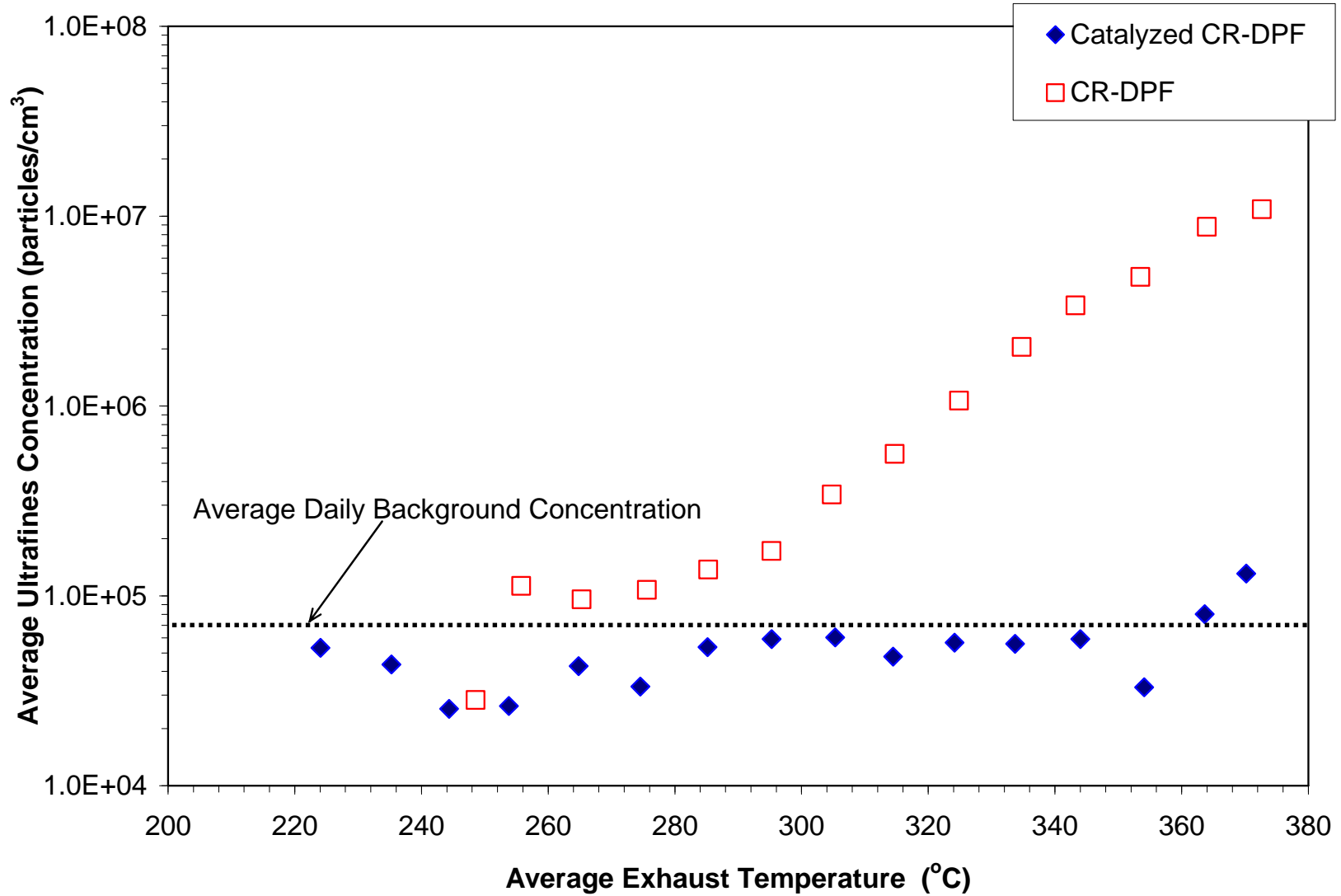
Ultrafine mass Sulfur control OUT



3. Control Volatile Content OUT



Ultrafine number Volatile control OUT



What Did We Find?



- Sulfur control IN and OUT results:
 - Sulfur from fuel and oil can play an important role in ultrafine emissions
- Volatile control OUT results:
 - Catalyzed CR-DPF is very effective at removing volatiles that may have formed ultrafines after leaving the tailpipe



What Does All This Mean?



- Engines emit gases, particles and volatiles all at once
- Many of these components interact with each other as they pass through the tailpipe
- The presence of the emission control device changes the nature of these interactions—but does NOT add to the total mass emissions
 - Apparent “creation” of ultrafines by device
- Through proper control of engine, fuel, oil, and device, even these interactions can be minimized
- In any case, based on current knowledge, using currently available emission control devices is still beneficial for both the environment and for human health



Acknowledgments



- Prof. David Kittelson (U of M)
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- Global Lubricants Technology, BP plc
- Corning, Inc.
- Volvo Technology Corporation



- JM: Johnson Matthey Inc.
- CR-DPF: Continuously Regenerating Diesel Particulate Filter
- PSD: Particle Size Distribution
- PM: Particulate Matter (used here in the context of particle mass)
- DOC: Diesel Oxidation Catalyst
- U of M: University of Minnesota
- MEL: Mobile Emissions Laboratory

